NSTS-23582

STS-29 National Space Transportation System Mission Report

April 1989

(NASA-TM-105484) STS-29 NATIONAL SPACE TRANSPORTATION SYSTEM MISSION REPORT (NASA) 33 p

N92-70440

Unclas
0064276

NASA
National Aeronautics and Space Administration

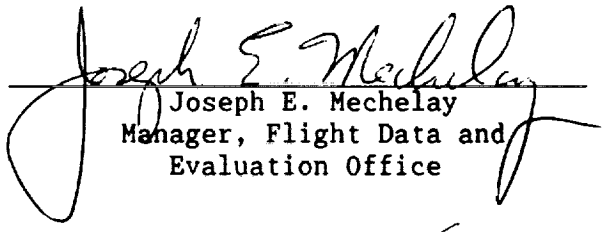
Lyndon B. Johnson Space Center
Houston, Texas

NSTS-23582

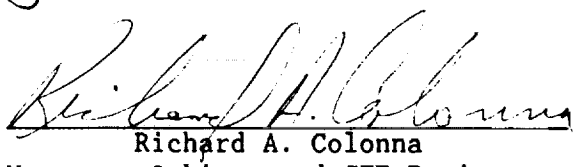
STS-29

NATIONAL SPACE TRANSPORTATION SYSTEM

MISSION REPORT



Joseph E. Mechelay
Manager, Flight Data and
Evaluation Office



Richard A. Colonna
Manager, Orbiter and GFE Projects

Richard H. Kohrs
Deputy Director, National STS Program

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER
HOUSTON, TEXAS 77058

April 1989

Table of Contents

Tables

INTRODUCTION

The STS-29 National Space Transportation System (STS) Program Mission Report contains a summary of the vehicle subsystems activities on this twenty-eighth flight of the Space Shuttle and this eighth flight of the OV-103 (Orbiter) vehicle, Discovery.

The primary objective of the STS-29 mission was to successfully deploy the Tracking and Data Relay Satellite-D/Inertial Upper Stage satellite. Secondary objectives were to perform all operations necessary to support the requirements of the Orbiter Experiment (OEX) Autonomous Supporting Instrumentation System (OASIS), Space Station Heat Pipe Advanced Radiator Element (SHARE), Protein Crystal Growth (PCG), Space and Life Sciences Training Program Chromosome and Plant Cell Division in Space (CHROMEX), IMAX Camera, Chicken Embryo Development in Space, Effects of Weightlessness in Space Flight on the Healing of Bones, and the Air Force Maui Optical Site (AMOS) calibration test payloads.

The crew for this mission was Michael L. Coats, Capt., U. S. Navy, Commander; John E. Blaha, Col., U. S. Air Force, Pilot; Robert C. Springer, Col., U. S. Marine Corps, Mission Specialist 1; James F. Buchli, Col., U. S. Marine Corps, Mission Specialist 2; and James P. Bagian, M.D., Mission Specialist 3.

The sequence of events for this mission is shown in Table I. This report also summarizes the significant problems that occurred during the mission. The problem tracking list is presented in Table II to provide a complete list of all Orbiter problems. Each of these problems is cited in the body of the report.

MISSION SUMMARY

The STS-29 mission was successfully launched at 72:14:57:00.017 G.m.t. (08:57:00.017 a.m. c.s.t.) on March 13, 1989. The launch countdown was held at T-9 minutes for 1 hour 50 minutes because of ground fog which subsequently cleared and winds aloft that were higher-than-allowed limits. Prelaunch analysis indicated that excessive vehicle structural loads would be present in the area of the the Orbiter wing leading edge, as indicated by analysis of the green squatcheloid. The load indicator for the wing leading edge is known to be more accurate in this case than the green squatcheloid in predicting margin of safety. Therefore, an Launch Commit Criteria (LCC) waiver was approved for the wing leading edge excessive loads, and the countdown was resumed. Additionally, wind data indicated External Tank (ET) structure loads would exceed the squatcheloid by one percent. Evaluation of the loads showed that the loads were within the ET structural capability, and an LCC waiver was processed for this excessive load. High surface winds were present at Edwards Air Force Base (AFB), and as a result, the abort-once-around (AOA) landing site was changed to Northrup Strip at White Sands, NM.

The launch phase was satisfactory in all respects. First stage ascent performance was satisfactory with Solid Rocket Booster (SRB) separation, entry, deceleration and water impact occurring as planned. Performance of the Space Shuttle main engines (SSME's), External Tank (ET), and main propulsion subsystem

(MPS) was as predicted with main engine cutoff (MECO) occurring at the predicted time. One Orbiter subsystem anomaly was noted during mated coast prior to ET separation when the reaction control subsystem (RCS) R1U thruster failed off at 72:15:05:45 G.m.t. The loss of this thruster did not impact the mission as two same-direction-firing pitch thrusters were still available in the right aft RCS. The exhaust gas temperature (EGT) 2 sensor on auxiliary power unit (APU) 3 failed momentarily during ascent, then recovered for a short period after which it again failed at APU shutdown. The sensor appeared to operate satisfactorily during entry. Following landing and APU shutdown, EGT 1 sensor on APU 1 also failed.

Analysis of ascent data has revealed that oxidizer flow control valves for SSME 1 and 3 were slow in opening, and this resulted in the ET liquid oxygen tank pressure decreasing to the lowest value experienced during flight operations. The slow-opening phenomenon did not impact MPS or ET operations during the mission.

A two-engine orbital maneuvering subsystem (OMS) 2 firing was performed satisfactorily at 72:15:36:58.106 G.m.t. The firing duration was 141.65 seconds (differential velocity of 222 ft/sec), and the Orbiter was inserted into a nominal orbit of 162.9 by 160.2 nmi.

The Tracking and Data Relay Satellite/Inertial Upper Stage (TDRS/IUS) was deployed on time at 072:21:10:12 G.m.t., and the planned solid rocket motor burns were performed. One reaction control system firing was also performed. The satellite is now in a geosynchronous orbit. All TDRS appendages were deployed nominally and the satellite is now in the planned operational position of 150 degrees West longitude.

A two-engine OMS 3 payload separation maneuver was performed at 72:21:24:46.987 G.m.t. The firing time was 16.82 seconds and the differential velocity was 31 ft/sec.

The power reactant storage and distribution (PRSD) subsystem hydrogen tank 3 exhibited erratic behavior within the 220- to 240-psia control band and was taken off line. Analysis of data showed that system hardware was operating properly and the tank was placed back in operation.

The text and graphics system (TAGS) was used to transmit over 660 pages of data during the mission. However, the TAGS exhibited overtemperature problems throughout the mission. This required that the TAGS be powered off during the TDRS-East satellite portion of each revolution to allow for cooling of the developer. This cycling of power to the TAGS allowed the successful use of the system throughout the remainder of the mission through the TDRS-West satellite.

At 74:00:58:30 G.m.t., a dump of the OPS-2 recorder was begun. When the recorder switched from track 5 to track 4, the data became noisy and synchronized lock could not be acquired. Analysis indicated only track 4 was bad and that track was not used for the remainder of the mission to ensure that all future recorded data could be downlinked and that the data on track 4 could be recovered postflight.

The flight control system (FCS) checkout was initiated at 76:09:42:08:84 G.m.t., and was completed normally with 5 minutes 10.5 seconds run-time on APU 2. Twelve

pounds of APU fuel were used for the checkout. The RCS hot-fire test was also completed satisfactorily with all RCS engines except R1U being fired for 80 msec each.

During payload bay door (PLBD) closure, the port side PLBD aft close limit switch in the ready-to-latch module failed to indicate closed. The automated door closure sequence was terminated and the crew manually completed PLBD closure.

All final entry preparations and stowage were completed, and the OMS deorbit maneuver was performed as planned at 077:13:35:15 G.m.t., with a differential velocity of approximately 313 ft/sec. Entry interface occurred at the nominal time, and all subsystem performance and entry operations were normal. For the first time, continuous data were received throughout the normal blackout period because of the use of the TDRS capabilities. Main landing gear touchdown occurred at 77:14:35:49.6 G.m.t. (08:35:49.6 a.m. c.s.t.) on concrete runway 22 at Edwards AFB, CA. Nose landing gear touchdown followed 11.0 seconds later with wheels stop at 77:14:36:40.7 G.m.t. The rollout, which required 9339 feet, was nominal in all respects. All postflight subsystem reconfigurations were completed as planned, and the crew egressed the Orbiter at 77:15:20 G.m.t.

A summary of payload operations indicates that all payloads performed successfully throughout the mission except the Space Station Heat Pipe Advanced Radiator Element (SHARE). The SHARE payload was unable to achieve normal operations because of the presence of vapor bubbles in the liquid channels. A number of unplanned Orbiter maneuvers were executed, but these were only partially successful in dislodging the bubbles. The Orbiter Experiment (OEX) Autonomous Supporting Instrumentation System (OASIS) payload operated nominally. Middeck payloads and payload integration hardware operated satisfactorily throughout the mission.

A summary of the detailed test objective (DTO) activities shows 15 of 18 planned DTO's and all 10 of the detailed supplementary objectives were accomplished. DTO 0790, Inertial Measurement Unit Reference Recovery Techniques, was only partially completed because of higher priority activities on the SHARE payload, and an anomaly with the crew optical alignment sight calibration data for the +X axis. DTO 0330, Water Dump Cloud Formation, was also impacted by SHARE operations. Dumps of both supply and waste water were desired, but only the supply dump was obtained on flight day 4. Winds at the Edwards AFB landing site were not conducive for DTO 0805, Crosswind Landing Performance.

SOLID ROCKET BOOSTER/SOLID ROCKET MOTOR PERFORMANCE

Lightweight solid rocket motor (SRM) cases were used for the STS-29 flight. The SRB prelaunch countdown was normal except for an anomalous primary heater circuit that failed on the right-hand aft field joint. After experiencing a small decline in the temperature of the joint, the secondary heater circuit was activated, and the temperature of the joint was maintained within limits for the remainder of the countdown. Postflight inspection revealed than an open circuit of the primary heater exists, and all four wires running from the heater to a connector had overheated.

All SRB systems performed as expected during ascent. SRM propulsion performance was normal and well within the specification limits. Propellant burn rates for both SRM's were near predicted values. SRM thrust differentials during the buildup, steady state, and tailoff phases were well within specification. All SRB thrust vector control prelaunch conditions and flight performance requirements were met with ample margin. All electrical functions were performed as planned. No Launch Commit Criteria (LCC) violations were noted.

The SRB flight structural temperature measurement response was as expected. Postflight inspection of the recovered hardware indicated that the SRB thermal protection system (TPS) performed as predicted during ascent with very little TPS acreage ablation. The left SRB nose cap (hemispherical "beanie" portion only) was recovered and was in excellent condition with no missing TPS or debonded areas evident.

Separation subsystem performance was normal with all booster separation motors expended and the separation bolts severed. Nose cap ejection, frustum separation and nozzle jettison occurred normally on each SRB. All drogue and main parachutes were recovered and are reusable.

The entry and deceleration sequence was performed as planned on both SRB's. SRM nozzle jettison occurred at apogee as scheduled, and all subsequent parachute deployments were nominal. However, excessive damage in the aft-skirt areas (hydraulic power units and associated hydrazine systems), which can be attributed to thermal causes, is considered to result from the early nozzle jettison. Postflight review of the parachute deployment films taken from the forward skirt dome cameras identified a foreign object traveling across the camera's field of view. Evaluation of the film has determined that the object is a lacing grommet from the parachute deployment bag.

Postflight analysis of the Shuttle range safety system indicates that the performance of the system on both SRB's and the ET was normal.

Several other in-flight anomalies have been documented as a result of observed damage in the SRB aft-skirt region. These anomalies covered damage to both left and right SRB thrust vector control system components, left SRB aft-skirt intermediate ring damage, a debonded area in the left SRB aft-center factory joint weather seal, missing portions of the glass phenolic liner at the left SRB aft exit cone, super lightweight ablator missing from the left SRB range safety antenna (minus Z axis), missing and fractured nuts on the left SRB backup ring, and structural damage to the right SRB frustum separation backup ring. All of these in-flight anomalies are associated with component reuse issues and are not flight safety concerns.

Postflight inspection of holddown post number 8 revealed that several pieces of hardware were missing from the post, including most of the NASA standard initiator (NSI) booster cartridge and three large slivers of the frangible nut. Inspection of the launch pad area revealed that pieces of debris found in the sand pit at holddown post number 8 were similar to the missing pieces. However, the sand pits were not thoroughly cleaned prior to launch and the total weight of the debris discovered was only 1.6 oz. Although films of the lift-off sequence show debris in the vicinity of holddown post number 8, additional evaluation is still required before any conclusions can be drawn.

EXTERNAL TANK PERFORMANCE

All objectives and requirements associated with the ET support of the launch countdown and flight were accomplished. Propellant loading was completed as scheduled, and all prelaunch thermal requirements were met. TPS acreage performance was as expected for the existing ambient conditions, and there was no violation of the ice/frost criteria. No ET LCC violations were experienced. However, the launch-minus-1-hour balloon wind data indicated loads exceeded the squatcheloids to which the ET structure had been previously cleared by one-percent. Evaluation of the loads associated with this condition showed that the loads were within the ET structural capability, and an LCC waiver was processed and approved for this excessive load.

During the liquid hydrogen fast-fill operation, a larger-than-normal amount of vapor and visible liquid was observed dripping from the region of the liquid hydrogen disconnect. The visible liquid diminished when the liquid hydrogen fast-fill rate was reduced. This condition is under investigation as this report is being published.

ET flight performance was excellent. All electrical equipment and instrumentation monitored on the ET performed satisfactorily. Separation and tumble initiation occurred as planned, and ET tumbling was verified by radar. Entry was normal with breakup and impact occurring in the footprint as predicted.

The slow opening of the oxidizer flow control valves discussed in the main propulsion system portion of this report caused the ET oxidizer tank pressure to decrease to the lowest value observed during a Shuttle launch. This low pressure did not impact the ET or its operations.

SPACE SHUTTLE MAIN ENGINE PERFORMANCE

All SSME parameters were normal throughout the prelaunch countdown, comparing well with predicted values and values observed on previous flights. All conditions for engine start were achieved at the proper times.

Flight data indicate that the SSME performance at main engine start, mainstage, and during shutdown and propellant dumping operations were within specification. High pressure oxidizer turbopump and high pressure fuel turbopump temperatures were near predicted values throughout engine operation. The SSME controllers provided proper control of the engines throughout powered flight, and no failures or significant problems were identified. Engine dynamic data compared well with previous flight and test data. All on-orbit activities associated with the SSME's were accomplished successfully.

During the postlanding inspection of the engines, an internal leak was discovered at the main combustion chamber-to-nozzle interface (joint G15) in SSME 1 (Serial No. 2031). Boroscope inspection of the main combustion chamber bond line confirmed the leak location to be in the area of nozzle tube 630. A subsequent ultrasonic inspection showed a single debonded area of approximately 0.4 inch.

ORBITER PERFORMANCE

The overall Orbiter performance was excellent with a total of 30 anomalies identified, none of which caused any impact to the mission objectives. All identified problems are discussed in the following sections of the report.

MAIN PROPULSION SUBSYSTEM

The overall performance of the MPS was excellent. Liquid oxygen and liquid hydrogen loading was performed as planned with no stop-flows or reverts. Propellant loads were very close to the predicted inventory loads. During preflight operations, no hazardous gas concentrations of any significance were detected. Maximum hydrogen level in the Orbiter aft compartment was 150 ppm, a value which compares well with previous data for this vehicle.

Trajectory reconstruction indicated that the vehicle specific impulse was near the MPS assessment tag values. Ullage pressures were maintained within required limits throughout flight. Feed system performance was normal.

The calculated liquid hydrogen load at the end of the replenish cycle was about 91 lbm more than the inventory load, a difference of only 0.039 percent. The calculated liquid oxygen load at the end of the replenish cycle was about 820 lbm more than the inventory load, a difference of only 0.059 percent. Liquid oxygen and liquid hydrogen propellant conditions were within specified limits during all phases of operation, and all net positive suction pressure (NPSP) requirements were met. Propellant dump and vacuum inerting were accomplished as planned.

Oxidizer flow control valve (FCV) 1 (SSME 1) and FCV 3 (SSME 3) delayed opening by 0.4 and 1.4 seconds, respectively, after the start command was given. Also, FCV 3 opened slowly, requiring 1.5 seconds to fully open (Flight Problem STS-29-04). This phenomena did result in the ET liquid oxygen tank pressure decreasing to the lowest value experienced during Shuttle flights, but the MPS operation was not impacted by the low pressure. Data showed that the valves operated normally on subsequent cycles.

Analysis of launch pad films revealed excessive vapor emanating from the area of the ET/Orbiter hydrogen umbilical from the start of liquid hydrogen loading until visual coverage was lost after lift-off (Flight Problem STS-29-06). Analysis of the data as well as photography of this area late in the countdown are in progress as this report is being published. Heavy vapor and numerous drops were also observed in the vicinity of the liquid hydrogen umbilical earlier in the countdown during the fast fill to 85 percent. Ice was noted on the umbilical, however, the ice team reported the ice buildup was not excessive and no temperatures were below 10 °F. The vapor drops were believed to be the result of heat leak phenomena, and a decision was made that the condition was no problem.

The postlanding inspection of the Orbiter revealed an audible leak of 1080 scim (maximum allowable - 1000 scim) in the 17-inch liquid hydrogen disconnect. Nicks were found in the flapper seal and the inner bore (Flight Problem STS-29-12).

Data analysis revealed that the liquid hydrogen 4-inch disconnect required about 5.7 seconds to close at shutdown. The specification for closure is a maximum of 2.3 seconds (Flight Problem STS-29-13).

Data analysis indicated that the SSME 1 liquid hydrogen prevalve opening was slow when compared with data from previous flights (Flight Problem STS-29-17). The data indicated an opening time of 1.813 seconds compared with the requirement of 1.5 seconds.

Data evaluation revealed that the liquid hydrogen feed manifold relief system only cycled once after MECO and prior to dump initiation (Flight Problem STS-29-21). While initially believed to be abnormal, review of data from previous missions showed this to be a common occurrence. Also, the liquid hydrogen outboard fill and drain valve closed slowly following termination of the post-MECO dump (Flight Problem STS-29-28). The valve required 11.5 seconds to close.

REACTION CONTROL SUBSYSTEM

The performance of the reaction control subsystem (RCS) was nominal except for the R1U thruster which failed on the initial firing about 2 seconds before ET separation (Flight Problem STS-29-01).

One additional minor concern was noted during the flight. Thrusters L5L and L5D exhibited chamber pressures for a short duration that were 40 to 60 psia below the nominal value of 110 psia. The thruster chamber pressures subsequently returned to nominal values for the remainder of the flight. The decrease in chamber pressure has been seen on previous flights and is attributed to residue buildup in the chamber pressure sensor tube as a result of extended thruster firings.

ORBITAL MANEUVERING SUBSYSTEM

Three orbital maneuvering subsystem (OMS) dual-engine maneuvers with a total firing time of 321.4 seconds were performed satisfactorily during STS-29. No anomalies were noted during the mission.

During the firing, the right OMS system A gaseous helium regulator appeared to be controlling at a lower-than-expected pressure (243 psia). Propellant tank pressures increased to 249 psia between OMS engine shutdown and helium tank isolation valve closure, indicating the regulator was operating. Analysis of data confirms that the right gaseous helium system A regulator set-point is at the low end of the operating range, which gave the appearance of a lower-than-expected operating pressure. However, data showed that the regulator was operating normally. Also, the pressures observed were consistent with checkout data and the observed operation is considered to be nominal.

Flight data showed that the left OMS fuel gage indicated an ungageable quantity during the OMS-2 and OMS-3 maneuvers. However, all indications were correct following the deorbit firing (Flight Problem STS-29-18).

POWER REACTANT STORAGE AND DISTRIBUTION SUBSYSTEM

The PRSD subsystem operated properly and provided all reactants (1095 lb of oxygen for the fuel cells, 45 lb of oxygen for crew breathing, and 138 lb of hydrogen for the fuel cells) required for successful mission completion. Based on the reactants remaining at landing (1190 lb of oxygen and 133.1 lb of hydrogen), a 4-day mission extension was feasible.

One anomaly was noted in that hydrogen tank 3 was taken off line when it exhibited unusual pressure fluctuations between 220 and 240 psia when hydrogen tank 3 heaters were energized after launch (Flight Problem STS-29-03). The manifold pressure showed several spikes of about 20 psi magnitude and one of 70 psi, peaking at 305 psi and opening the manifold relief valve. Review of STS-26 and STS-27 data revealed a similar pressure signature when tank 3 was on-line. Agreement was reached that the tank could be placed back in operation safely. Hydrogen tank 3 operation was resumed at 74:15:00 G.m.t. on heater A only. The pressurization rate and heater cutoff point were normal. Analysis of data indicated small manifold pressure oscillations of 2 to 5 psia during the first 10 minutes of the pressurization cycle, but these oscillations subsided during the latter part of the cycle. Tank 3 was reconfigured to heater B at 74:18:29 G.m.t., and the tank and manifold pressures cycled normally within the control band. Small pressure oscillations were again observed; however, the tank was safe to operate as required for the remainder of the mission. All items powered down during the PRSD tank 3 inoperative period were successfully returned to operation.

FUEL CELL POWERPLANT SUBSYSTEM

The fuel cells performed as predicted and satisfactorily provided 1613 kWh of electricity at an average power level of 13.5 kW while producing 1233 lb of water during the mission. Actual fuel cell voltages averaged 0.3 V above predicted for fuel cell 1, 0.2 V above predicted for fuel cell 2, and 0.1 V above predicted for fuel cell 3. No problems were identified during the 171.5 hours of fuel cell operation.

On flight day 3, the crew configured the fuel cell water relief heaters to the B AUTO position in accordance with standard procedures. The B thermostat immediately turned the heater on as the temperature was 70 °F and the thermostat set point was about 75 °F. The temperature rose to 130 °F, well above the normal thermostat cutoff point, before any cooling was observed (Flight Problem STS-29-16). Two more temperature spikes into the 120 to 130 °F range were seen during the flight. The nominal temperature range is 70 to 105 °F.

AUXILIARY POWER UNIT SUBSYSTEM

The APU subsystem performed satisfactorily throughout the mission and the postlanding operational period. APU 1 operated for 01:48:52, APU 2 operated for 01:28:02, and APU 3 operated for 01:22:51, with all three APU's operating for 20 minutes and 30 seconds after landing. A total of 662 lb of fuel was consumed by the APU's during the almost 280 minutes of operation.

The exhaust gas temperature (EGT) 2 sensor on APU 3 failed momentarily during ascent, then recovered for a short period after which it again failed at APU shutdown (Flight Problem STS-29-02a). The sensor appeared to operate

satisfactorily during entry. Following landing and APU shutdown, EGT 1 on APU 1 began cycling erratically between 270 °F and 930 °F (Flight Problem STS-29-02b) while EGT 2 on APU 1 indicated normal temperatures.

HYDRAULICS/WATER SPRAY BOILER SUBSYSTEM

The hydraulics/water spray boiler subsystem performed satisfactorily throughout the mission; however, four anomalies were noted. Water spray boiler 3 relief valve reseated at 26.7 psia, which is 1.3 psia below specification (Flight Problem STS-29-10). Also, water spray boiler 1 exceeded the specification leakage (0.06 psia/hr vs. 0.04 psia/hr) early in the mission (Flight Problem STS-29-11). Also, following APU shutdown after ascent, the hydraulic system 1 and 2 gaseous nitrogen accumulator pressures locked up at 2544 and 2496 psia, respectively, which was below the acceptable level of 2600 psia (Flight Problem STS-29-26). The pressures slowly rose to acceptable levels later in the mission and the system operated properly.

During the postflight inspection, 1/2 to 1 ounce of hydraulic fluid were found in the aft compartment. Further inspection revealed a loose B nut in the leakage collection line from the SSME 1 accumulator (Flight Problem STS-29-23). This line is an unpressurized dead-ended line, and this condition had no impact on subsystem performance.

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SUBSYSTEM

The performance of the atmospheric revitalization subsystem, pressure control subsystem, active thermal control subsystem, supply and waste water subsystem, and the waste collection system was satisfactory with only one anomaly being noted. In preparation for entry, the crew switched the flash evaporator system (FES) controller to the Primary GPC position. The typical transient phenomena associated with switching FES controllers caused a brief FES evaporator outlet temperature excursion to about 60 °F. At approximately 04:20:44:37 mission elapsed time, the FES overtemperature comparator reached its 55-second limit for time spent above 41.5 °F and shut down the FES evaporator.(Flight Problem STS-29-14).

AVIONICS SUBSYSTEMS

The avionics subsystems operated satisfactorily throughout the mission. The use of the TDRS resulted in data acquisition during the period when entry blackout normally occurs. This was the first manned flight of the American space program in which no entry blackout has occurred. Several minor anomalies occurred during the course of the mission, and these are discussed in the following paragraphs.

At 72:21:18 G.m.t. (approximately 8 minutes after payload deployment), the payload interrogator (PI) lost lock on the IUS 16 kbps data. At the same time, the payload data interleaver (PDI) continued to intermittently process the IUS data. Telemetry showed a PI channel selection of 006 instead of the expected 906. After the crew cycled the PI channel select thumbwheels, the problem cleared and the PI channel showed 906 and the PDI indicated lock (Flight Problem STS-29-05). The anomaly did not impact the flight.

The crew optical alignment sight (COAS) was used on flight day 3 to obtain X-axis calibration data. While performing DTO 790 on flight day 5, the +X-axis

(horizontal) calibration data differed by 0.5 to 0.6 degree from those marks taken on flight day 3 (Flight Problem STS-29-15). Previous flight experience has shown that the COAS can be taken down and remounted with essentially repeatable marks.

At 73:19:28 G.m.t., a developer overtemperature condition in the text and graphics system (TAGS) was indicated (Flight Problem STS-29-07a). The TAGS was powered down and allowed to cool, however a second overtemperature indication occurred after power was reapplied. To ensure that the TAGS was available to receive data during TDRS-West passes, the unit was powered off during most of each TDRS-East pass by ground command. The period of cooling allowed the TAGS to support the TDRS-West passes without an overtemperature indication occurring. Troubleshooting was performed on the TAGS overtemperature problem by not cycling power for 4 hours, after which another overtemperature indication was observed and the power was again cycled to clear the problem. TAGS power was cycled each orbit and the system continued to operate for the remainder of the mission with over 660 pages transmitted and successfully printed. Use of the TAGS in this manner did not impact crew operations.

On two occasions during the flight, the TAGS changed from the ready to the standby mode during uplinking and in the middle of a page (Flight Problem STS-29-7b). In both cases, the TAGS was commanded to ready and the pages were re-uplinked successfully.

Synchronizer lock on the data on track 4 of the operations (OPS) 2 data recorder could not be obtained when the data were dumped (Flight Problem STS-29-08). Attempts were made at more than one site to dump track 2 of the recorder in both forward and reverse and these were unsuccessful. All other tracks of the recorder were accessible for dumping throughout the mission. Late in the flight when dumping the OPS 1 recorder, numerous unsuccessful attempts were made to dump track 2 through the TDRS to the Ground Space Flight Tracking and Data Network (Flight Problem STS-29-20). After reconfiguration of the ground network late in the mission, successful dumps of track 2 were made. However, following landing, the problem with track 2 recurred, and data on adjacent tracks remained accessible.

During the crew debriefing, the crew stated that on one occasion the aft AUTO light for the Orbital DAP (digital autopilot) was not illuminated while the forward AUTO DAP light was illuminated (STS-29-24). A lamp test at that time verified that the lamp was operational. Later in the mission, the light was noted to be operating properly.

The SSME 3 power supply temperature was erratic throughout the powered flight phase (STS-29-02c). Troubleshooting at KSC located a wire that was pulled out of the backshell of a connector on the Orbiter side of the interface.

The crew reported that battery changes were required much too frequently for the wireless communications headset (Flight Problem STS-29-29). The batteries were known to be marginal and have been removed from flight status.

TACAN 2 lost range and bearing lock after landing (Flight Problem STS-29-27). This loss had no effect on the mission.

MECHANICAL SUBSYSTEMS

The mechanical and brake subsystems operated in a nominal manner with only four minor anomalies which are discussed in the following paragraphs.

When closing the payload bay doors prior to the deorbit maneuver, the port B (aft) close limit switch in the ready-to-latch module failed to indicate closed (Flight Problem STS-29-09). Closing of the door was completed manually with no impact on the mission.

The right main landing gear tire pressure instrumentation (strain gage wiring and connector) were found on the runway following landing (Flight Problem STS-29-22). It is believed that this loose harness may have caused tile damage that was found aft of the right main landing gear door.

The postlanding inspection revealed that the aft separation hole plugger (piston) did not extend the full-stroke distance (Flight Problem STS-29-19). The piston is to contain pyrotechnic debris to prevent contamination of other nearby mechanisms that would prevent normal operation of the ET doors. All debris was accounted for within the hole plugger containment and no debris or damage was observed outside the device.

During postflight inspection of the brake assemblies, a crack was found in the right-hand outboard brake rotor (Flight Problem STS-29-30).

THERMAL CONTROL SUBSYSTEM

The thermal control subsystem heater performance was nominal throughout the mission and all temperatures were maintained within acceptable limits. Five dithering thermostats were identified, but were of no concern to the successful completion of the mission. Two thermal transducers associated with the APU subsystem (APU 3 EGT 2 and APU 1 EGT 1) failed and these are discussed in the APU section of this report.

The down-firing aft vernier thrusters (L5D and R5D) and their propellant feedlines experienced higher-than-usual temperatures [200 °F compared to Shuttle Operational Data Book (SODB) limit of 150 °F]. Preliminary evaluation indicated that an unusually tight attitude control band resulted in a higher-than-normal rate of engine firing followed by a 30-second period of where no engines fired, and this allowed heat soakback to cause excessive feedline temperatures. Preliminary analysis has indicated that the 150 °F SODB limit may be too restrictive and an evaluation of this condition is continuing.

THERMAL PROTECTION SUBSYSTEM AND AEROTHERMODYNAMICS

The thermal protection subsystem (TPS) performance was nominal, based on analysis of the structural temperature response, as well as tile surface temperature measurements. The overall boundary layer transition from laminar to turbulent flow occurred 1100 seconds after entry interface. Based on the preflight trajectory, the nose area analytical equivalent roughness (Keq) was calculated to be 0.130 inch compared to the requirement of 0.140 inch and the maximum measured value of 0.135 inch. The thermal protection subsystem damage was minimal with most of the damage on the high-temperature reusable surface insulation (HRSI) tiles on the midfuselage and near the right main landing gear.

The vehicle sustained 132 debris hits of which 23 had a major dimension greater than 1 inch. Of the total number of hits, the Orbiter lower surface sustained 100 hits with only 18 hits greater than 1 inch. In addition, two long gouges (8 inches and 10 inches) were noted aft of the right main landing gear door, and this damage is believed to be caused by the tire pressure instrumentation that was found on the runway following landing. The base heat shield peppering was minimal with a larger concentration of hits between the three engine nozzles.

The chin panel tile modification showed several degraded repairs and some slumped repairs. The nose landing gear door thermal barrier leading edge outer mold line (Nicalon) barrier was debonded with the secondary thermal barrier starting to debond. There were several instances of advanced felt reusable surface insulation (AFRSI) leading edge fraying or protrusion. The ET door thermal barriers were judged acceptable for ferry flight and acceptable for re-flight. The elevon-to-elevon gap showed 10 breached gap fillers on the right-hand side and 4 on the left-hand side. The SSME-mounted heat shield thermal curtains were severely damaged, with some sections of the outer material missing and inner layers exposed on SSME 1 and 3. SSME 2 curtain was nominal. Also, windows 1 through 5 appeared hazy with windows 1 and 3 having streak marks.

During the postflight inspection at KSC, the two top thermal blankets were found torn on the aft bulkhead side. In addition, loose snaps were found on top of blankets with four blankets (two on each side of the centerline) peeled back (Flight Problem STS-29-25). Also, a larger-than-expected amount of particle contamination was noted inside the payload bay. The source of this contamination is believed to be the thermal blankets.

PAYLOADS

The STS-29 payloads performed exceptionally well except for the SHARE experiment. This experiment had vapor bubbles present in the liquid channels, and the bubbles prevented normal operations. The crew performed numerous RCS maneuvers in an attempt to move or dislodge the bubbles, but all attempts were unsuccessful. The payloads and experiments flown on STS-29 were as follows:

a. TDRS-D/IUS-2
b. Space Station Heat Pipe Advanced Radiator Element (SHARE)
c. Orbiter Experiment (OEX) Autonomous Supporting Instrumentation System (OASIS)
d. Chromosome and Plant Cell Division Experiment (Chromex)
e. Protein Crystal Growth (PCG) Experiment
f. IMAX Motion Pictures
g. Air Force Maui Optical Site (AMOS) Test
h. Shuttle Student Involvement Projects (SSIP)
    1. 82-8 - Effects of Weightlessness in Healing of Bones
    2. 83-9 - Chicken Embryo Development in Space

The TDRS-D/IUS was deployed on time at 072:21:10:12 G.m.t., and all planned IUS burns were completed. The satellite was placed in a geosynchronous orbit and

drifted at a rate of 3 degrees/day to its operational position at 150 degrees West longitude. Checkout activities were in progress as this report was being written.

The IMAX camera malfunctioned when the drive belt jumped off the damper pulley. The crew followed normal malfunction procedures and reseated the belt. Some film was exposed as a result of this replacement, however, the camera operated satisfactorily for the remainder of the mission.

DETAILED TEST OBJECTIVES AND DETAILED SUPPLEMENTARY OBJECTIVES

Preliminary data indicate that 15 of the 18 DTO's were satisfactorily accomplished and all 10 of the planned detailed supplementary objectives (DSO's) were satisfactorily accomplished during STS-29. DTO 0790, inertial measurement unit reference recovery techniques, was only partially completed because of higher priority activities on the SHARE payload. DTO 0330, water dump cloud formation, was also impacted by SHARE operations. Dumps of both supply and waste water were desired, but only the supply water dump was completed on flight day 4. Winds at the Edwards Air Force Base landing site were not conducive to accomplishing DTO 0805, crosswind landing performance.

All of the Detailed Supplementary Objectives (DSO's) were accomplished. A listing of each DSO is contained at the end of this section.

DETAILED TEST OBJECTIVES

A listing of the 18 DTO's assigned to the mission follows:

DTO No.	DTO Title
312	ET TPS Performance (Method 2)
318	Direct Insertion ET Tracking for the Eastern Test Range
330	Water Dump Cloud Formation
333	Ascent Debris
517	Nosewheel Steering Runway Evaluation (Test No. 2)
518	Revised Braking System Test (Third Flight Test)
786	Text and Graphics System
787	Attitude Match Update
789	Payload and General Support Computer Evaluation
790	Inertial Measurement Unit Reference Recovery Techniques
805	Crosswind Landing Performance
301D*	Ascent Structural Capability Evaluation
305D*	Ascent Compartment Venting Evaluation
306D*	Descent Compartment Venting Evaluation
307D*	Entry Structural Capability
308D*	Vibration and Acoustic Evaluation
311D*	POGO (Longitudinal Oscillation) Stability Performance
319D*	Shuttle/Payload Low Frequency Environment

* Data only test

Preliminary results of the completed DTO's are provided in the following paragraphs.

0312 - External Tank Thermal Protection System Performance (Method 2) - This DTO was performed following ET separation with an attitude maneuver (no translation) to photograph the ET from the Orbiter overhead windows. Equipment used consisted of a hand-held Hasselblad camera, a 70-mm lens and a 5017 film magazine. Postflight processing of film shows good results. Approximately 100 good quality photographs were taken from the overhead windows.

0318 - Direct Insertion External Tank Tracking for the Eastern Test Range - The purpose of this DTO was to optically photograph the ET during entry to determine the rupture altitude of the liquid hydrogen tank and if differential velocity was imparted to the debris when rupture occurred. Rupture altitude affects the size of the ET footprint so data of this type are needed for ET certification and to determine if the ET tumble system can be removed. Actual rupture altitude data are needed to verify the Contractor assumptions for determining if the theoretical rupture altitude is reasonable. Good photographic results were obtained from the Cast Glance (P-3) aircraft. The ET rupture was described as violent and occurred at an estimated altitude of 240,000 feet.

0330 - Water Dump Cloud Formation - This DTO was impacted by higher priority operations for the SHARE payload. Observation of both supply and waste water dumps was desired. Supply water was dumped successfully on flight day 4 and was observed on onboard closed-circuit television and from the Hawaii tracking site.

0333 - Ascent Debris - The purpose of this DTO is to assess the presence and source of SRB debris during launch and ascent. A DBM-45 16-mm camera was mounted on top of the pilot's panel glare shield. The camera was actuated at lift-off by a lanyard to a toggle switch with good photographic coverage. Running time of the film was about 160 seconds, which is well past the SRB separation time.

0517 - Nosewheel Steering Runway Evaluation (Test no. 2) - Test no. 2 was planned for a lakebed landing, however, the landing occurred on concrete runway 22 instead. The test conditions were not the same as planned for the lakebed runway, but excellent data were obtained at high speed, and these data are being evaluated. Results of this evaluation will be presented as supplemental information to this report.

0518 - Revised Braking System Test (Third Flight Test) - This DTO was planned for a normal lakebed landing using nominal procedures with braking initiated at 140 knots and kept at a level to maintain a deceleration rate of 10 lb-ft sec^2. The same procedure was used for the landing on a concrete runway. Analysis of the braking data are continuing and the results will be reported as supplemental information to this report.

0786 - Text and Graphics System (TAGS) - A considerable amount of testing was accomplished for this DTO. More than 660 pages were processed and this depleted the system paper supply. Interesting findings from evaluation of this DTO are:

a. About 30 pages is the practical maximum in the tray before a threat of jamming occurs.

b. Power-on jams were explained by not waiting an adequate period of time after the final piece of paper is fed before powering off the equipment.

c. A thermal problem developed while using the equipment during the mission (Flight Problem STS-29-07).

0787 - Attitude Match Update - The purpose of this DTO is to test a procedure needed to update the inertial measurement unit attitude base to obtain the required accuracy for the planetary missions (Magellan, Galileo, and Ulysses). The launch delay slipped the attitude match update data-take opportunities, and this affected the Consolidated Satellite Test Center (CSTC) operations as discussed in the following paragraphs.

a. Data-take 1 was nominal at both the CSTC and the Huntsville Operations Support Center (HOSC), which is at the Marshall Space Flight Center.

b. The CSTC was not able to synchronize operations with the flight crew on data-take 3 or 4. The CSTC printer can only operate continuously for 3 minutes at a time, and the printer was not started at the right time to capture the last two data takes. The data takes were captured at the HOSC. CSTC recovered the data by tape playback, however this delayed the analysis from data-take 3 and 4 for 1 hour. CSTC was successful, however, in generating an attitude update based on data from takes 1, 3, and 4 about 1 hour prior to TDRS deployment. The consensus was that had data-take 3 and 4 been captured in real time, no difficulty would have been experienced in generating the uplink with adequate time to spare. Notification from the flight crew that the attitude-match update data take was imminent would greatly aid the CSTC attitude-match update operations.

c. In spite of the problems associated with obtaining data, CSTC and the HOSC agreed on the update, which was prepared in time for the TDRS deployment (goal of DTO).

0789 - Payload and General Support Computer Evaluation - The payload and general support computer (PGSC) is a portable computer that provides a common crew interface for a variety of STS payloads. The PGSC will be used to replace the SPOC (Shuttle Portable Onboard Computer). The computer was activated on time at 01:00:21 mission elapsed time. The crew reported that the PGSC LCD display was essentially unreadable when viewed from any angle other than directly in front of the screen. This problem is still being evaluated as this report is being published. On flight day 3, Orbiter power was terminated and the computer was placed on battery power for 2.5 hours. This occurred after a battery charge period of 24 hours. The crew reported that all PGSC temperatures were below 100 °F.

0790 - Inertial Measurement Unit Reference Recovery Techniques - This DTO consists of crew activities on-orbit using various techniques in support of the inertial measurement unit reference recovery after an unforeseen loss. The COAS and the universal pointing software are used with celestial targets that are easily identified. The objective of this DTO is to verify the operational feasibility of each technique. This DTO was scheduled for flight day 5, but was only partially completed because of higher priority activities on the SHARE payload. Some +X COAS calibration anomalies also were noted (Flight Problem

STS-29-15), and these are discussed in the Avionics Subsystems section of this report.

0805 - Crosswind Landing Performance - This DTO requires the flight crew to perform a manually controlled landing in the presence of a 90-degree steady-state crosswind of 10 to 15 knots. The wind conditions at Edwards Air Force Base were not sufficient to allow accomplishment of this DTO.

0301D, 0305D, 0306D, 0307D, 0308D, 0311D and 319D - These data-only DTO's require extensive postflight analysis of the mission data. The results of these DTO's will be presented as supplemental information to this report. The titles of the DTO's are shown in the beginning of this section of the report.

DETAILED SUPPLEMENTARY OBJECTIVES

A listing of the DSO's assigned to this mission is contained in the following table.

DSO	Title
0457	Inflight Salivary Pharmacokinetics of Scopolamine and Dextro-amphetamine
0458	Salivary Acetaminophen Pharmacokinetics
0462	Noninvasive Estimation of Central Venous Pressure During Space-flight
0468	Preflight Adaptation Training
0470	Relationship of Space Adaptation Syndrome to Middle Cerebral Artery Blood Velocity Measured In-flight by Doppler
0901	Documentary Television
0902	Documentary Motion Picture Photography
0903	Documentary Still Photography
0466	Preflight and Postflight Cardiovascular Assessment
0467	Influence of Weightlessness on Baroreflex Function

PHOTOGRAPHIC AND VIDEO SUMMARY

Satisfactory engineering documentary launch, on-orbit, and landing photographic coverage was provided with data being received from 29 video cameras and 86 of 92 photographic cameras that were documenting the launch activities. One hundred excellent photographs were taken of the ET by the flight crew. Data were received from six video cameras and 15 photographic cameras that were documenting the landing activities.

LAUNCH COVERAGE

Replay of launch coverage by 15 video cameras began 16 minutes after lift-off and six tracking video cameras began 12 hours after lift-off. The video coverage obtained from airborne cameras was delivered to JSC by T-38 aircraft the afternoon of launch. Screening of the data identified a dark object which appeared to strike the vehicle at lift-off and a flash off the left side of the vehicle. The dark object was later identified as a bird that did not strike the vehicle, and the flash (bright puff) is still under investigations as this

report is being published. Detail analysis of the film shows excessive vapor emanating from the liquid hydrogen interconnect interface at the Orbiter (Flight Problem STS-29-06). The investigation of this problem continues as this report is being published.

A total of 86 of the 92 expected launch films and 29 of the 29 video playback data were received. Six photographic cameras (E-4, E-16, E-18, E-54, E-219, and EX2) did not run during the mission. As a result, some detail was lost, but overlapping coverage by other cameras provided sufficient detail to evaluate vehicle safety. Also, two films and three video tapes of the ET entry were received and analyzed. Two films from a special Photosonics camera test have also been received and will be evaluated at a later date.

High-altitude films of the launch phase appear to be a useful analysis product when compared with film from ground tracking cameras. Additionally, film taken during the launch phase from the crew cabin showed pieces of debris (butcher paper) that could be tracked back to a position on the vehicle. Based on the analysis of the film as well as the speed of the debris, a camera with a minimum speed of 100 frames per second is required for this coverage.

ONBOARD COVERAGE OF EXTERNAL TANK

The onboard film of the ET show excellent detail in many of the frames. One hundred pictures were taken, 96 of which show the ET centered in the frame. Both the ET and the four pieces of white debris are visible in frames with space as the background. The minimum and maximum size and velocity of the debris was measured and the debris analysis is continuing as this report is being published. Analysis of selected frames indicate the burn scar on the ET contains pixels which classify (look like) bare metal. One large divot that is somewhat oval in shape was identified on the intertank and measured 24 by 36 inches. Other divots have been noted on the intertank and on the closeout area where the intertank and hydrogen tank meet. Analysis of this scar data continues as this report is being written.

LANDING COVERAGE

Live coverage of the landing on runway 22 at Edwards Air Force Base appeared normal. Video replays of the data from Dryden Flight Research Facility (DFRF) began about 1 hour after landing. Evaluation of this coverage revealed no anomalies. Ten landing films including the engineering films from the Point Mugu trackers were also received. These films provided good coverage of the vehicle and evaluation revealed no anomalies, although some damage was apparent on the vehicle thermal protection system. Additionally, live video coverage of the TPS-survey walkaround inspection was received at JSC about 40 minutes after landing.

TABLE I.- STS-29 SEQUENCE OF EVENTS

Event	Source	Actual time, G.m.t.
APU activation	APU-1 GG chamber pressure	072:14:52:10.311
	APU-2 GG chamber pressure	072:14:52:11.891
	APU-3 GG chamber pressure	072:14:52:13.771
SRB HPU activation	LH HPU system A start command	072:14:56:32.202
	LH HPU system B start command	072:14:56:32.361
	RH HPU system A start command	072:14:56:32.521
	RH HPU system B start command	072:14:56:32.681
Main propulsion system start	Engine 3 command accepted	072:14:56:53.426
	Engine 2 command accepted	072:14:56:53.578
	Engine 1 command accepted	072:14:56:53.701
SRB ignition command (lift-off)	SRB ignition command to SRB	072:14:57:00.017
Throttle down to 66 percent thrust	Engine 3 command accepted	072:14:57:28.547
	Engine 2 command accepted	072:14:57:28.578
	Engine 1 command accepted	072:14:57:28.582
Maximum dynamic pressure (q)	Derived ascent dynamic pressure	072:14:58:07.065
Throttle up to 104 percent thrust	Engine 3 command accepted	072:14:57:57.508
	Engine 2 command accepted	072:14:57:57.539
	Engine 1 command accepted	072:14:57:57.543
Both SRM's chamber pressure at 50 psi or below	RH SRM chamber pressure mid-range select	072:14:59:00.900
	LH SRM chamber pressure mid-range select	072:14:59:01.020
End SRM action	RH SRM chamber pressure mid-range select	072:14:59:03.820
	LH SRM chamber pressure mid-range select	072:14:59:04.120
SRB separation command	SRB separation command flag	072:14:59:06.000
SRB physical separation	SRB physical separation	072:14:59:06.110
Throttle down for 3g acceleration	Engine 3 command accepted	072:15:04:30.798
	Engine 2 command accepted	072:15:04:30.827
	Engine 1 command accepted	072:15:04:30.835
3g acceleration	Total load factor	072:15:04:31.639
MECO	MECO command flag	072:15:05:29.591
	MECO confirm flag	072:15:05:30.820
ET separation	ET separation command flag	072:15:05:48.055
APU deactivation	APU-1 GG chamber pressure	072:15:11:06.491
	APU-2 GG chamber pressure	072:15:11:08.931
	APU-3 GG chamber pressure	072:15:11:09.551

TABLE I.- CONCLUDED

Event	Source	Actual time, G.m.t.
OMS-2 ignition	Right engine bi-prop valve position	072:15:36:58.106
	Left engine bi-prop valve position	072:15:36:58:362
OMS-2 cutoff	Right engine bi-prop valve position	072:15:39:19.761
	Left engine bi-prop valve position	072:15:39:19.966
TDRS/IUS deploy	Voice call	072:21:10:12
OMS-3 ignition	Left engine bi-prop valve position	072:21:24:46.987
	Right engine bi-prop valve position	072:21:24:46.987
OMS-3 cutoff	Left engine bi-prop valve position	072:21:25:03.813
	Right engine bi-prop valve position	072:21:25:03.813
Flight control system checkout		
APU start	APU-2 GG chamber pressure	076:09:42:08.840
APU stop	APU-2 GG chamber pressure	076:09:47:19.352
APU activation for entry	APU-1 GG chamber pressure	077:13:26:14.072
	APU-2 GG chamber pressure	077:13:52:14.165
	APU-3 GG chamber pressure	077:13:52:15.818
Deorbit maneuver	Right engine bi-prop valve position	077:13:35:15.002
	Left engine bi-prop valve position	077:13:35:15.198
Deorbit maneuver cutoff	Right engine bi-prop valve position	077:13:37:56.949
	Left engine bi-prop valve position	077:13:37:57.069
Entry interface (400k)	Current orbital altitude above reference ellipsoid	077:14:05:11.390
Blackout end	Data lock-on at high sample rate	No blackout because of TDRS-W
Terminal area energy management	Major mode change (305)	077:14:29:35.256
Main landing gear contact	LH MLG weight on wheels	077:14:35:51.536
	RH MLG weight on wheels	077:14:35:49.625
Nose landing gear contact	NLG weight on wheels	077:14:36:00.615
Wheels stop	Velocity with respect to runway	077:14:36:40.700
APU deactivation	APU-1 GG chamber pressure	077:14:56:06.501
	APU-2 GG chamber pressure	077:14:56:08.457
	APU-3 GG chamber pressure	077:14:56:10.093

TABLE II.- STS-29 PROBLEM TRACKING LIST

PROBLEM TRACKING LIST		STS-29/OV103		DATE 4-27-89	PAGE 1
NO.	TITLE	TIME	COMMENTS	MOD NO.	RESP. MGR.
STS-29 -01	RCS Jet R1U Failed Off During Mated Coast.	072:15:05 IPR 33RV-0023 PR-RP03-0318	Reaction control system jet R1U failed off during mated coast due to low chamber pressure. Trickle current test was performed and verified electrical path was good. Based on injector temperatures, the oxidizer propellant valve is suspected to have failed closed. R & R required. Verified trickle current test ok. Thruster will be changed. Remove RH POD for repair. 4/28 scheduled. Thruster to be removed and sent to vendor. Spare will be installed. Closed.	PROP-01	G. Grush X33090 T. Welch X33335
STS-29 -02	Instrumentation: (a) APU 3 EGT 2 Erratic (V46T0340A)	072:14:57 CAR/29RF03 PR-APU-09-0178	Auxiliary power unit 3 exhaust gas temperature 2 dropped about 100° during ascent, regained normal reading and dropped again post-MECO. KSC will T/S. R/R if required. OMI V1019 will verify. Closed.	MMACS-01	J.Miller x36908 D.Corcoran X33329
	(b) APU 1 EGT 1 Failed (V46T0142A)	077:14:56 CAR/29RF14 PR-APU-3-09-177	At APU shutdown postlanding, APU 1 exhaust gas temp. XDCR 1 became erratic, cycling between approx. 270°F and 930°F. APU 1 EGT 2 indicated normal temperature. KSC will T/S. R/R if required. OMI V1019 will verify. Closed.	MMACS-03	
	(c) SSME 3 PWR. Supply Temp. Erratic	IPR 33RV-0022 F/D E41T3150A	SSME 3 power supply temperature erratic from SSME start to shutdown. KSC T/S found wire pulled out of backshell of connector 50P446. Repair on PR. PR will close. PR-EPD-3-09-1123. Closed.		

NASA-JSC

JSC Form 318 (Feb 81)

TABLE II.- STS-29 PROBLEM TRACKING LIST

PROBLEM TRACKING LIST		STS-29/OV103		DATE 4-27-89	PAGE 2
NO.	TITLE	TIME	COMMENTS	MOD NO.	RESP. MGR.
STS-29 -03	PRSD Cryo H_2 Tank 3 Pressure High and Manifold Pressures Erratic	072:17:06 CAR/29RF01	The power reactant storage and distribution cryogenic hydrogen tank 3 pressure was erratic. Manifold pressures also indicated several pressure spikes. Similiar behavior has been observed on other flights. Tank 3 put back into operation at MET 2:00:00 and tank and manifold pressures behaved normally for remainder of flight. Dwny provide analysis and written report to close problem to JSC.	EECOM-02	F. Plauche X39034 D. Dillman X31733
STS-29 -04	OX FCV 1 Delayed Start To Open And FCV 3 Opened Slowly	072:14:57 CAR/29RF04 IPR33RV-0021 CAR/29RF08 PR-MPS-0682	The oxygen flow control valves 1 and 3 had a delayed start to open and the oxygen flow control valve 3 opened slower than normal. Data showed that in subsequent cycles, the valves operated normally. Sluggish opening during the first open cycle has been observed on other flights. Valves will be removed for inspection. Chit J2951. Appd. 3/27. Current trace test 4/11. Flow control valves out. Sent to Eaton via Dwny. Reinstall in OMRF.	BSTR-01	D. Prevett X39036 S. McMillan X35913
STS-29-05	PI Channel 1 Erroneous Reading	072:21:19 CAR/29RF05 PR-DDC-3-09-0051 IPR33RV-0026	Post-TDRS deploy, the payload interrogator (PI) 1 started sweeping, which is an indication of a loss of PI Lock. The PI 1 channel 906 was reading 006 on the ground. During this time, Sunnyvale reported TDRS frame sync while the PI did not show lock, which is a known condition in the IUS CIU. Crew cycled thumbwheel for PI 1 channel, and PI locked with good data out. Chit J2952. Appd. 3/30 R/R A1L panel. Panel R/R. Retest ok. Will U.A. as sticky thumb wheel. Replaced with push wheel. Closed.	INCO-01	E. Dickinson X31717 D. Suiter X33339

NASA ISC

TABLE II.- STS-29 PROBLEM TRACKING LIST

PROBLEM TRACKING LIST		STS-29/OV103		DATE 4-27-89	PAGE 3
NO.	TITLE	TIME	COMMENTS	MOD NO.	RESP. MGR.
STS-29-06	Excessive Vapor at H2 ET/ORB Umbilical Area Prelaunch	L-10 seconds CAR/29RF06	Excessive vapor was seen in the hydrogen external tank/Orbiter umbilical area during prelaunch. Chit J2954. Appd. 3/27. MSFC do special tests. KSC install leak detector. Chit 2981 pending. Launch criteria being developed. PRCB 4/26. Open.	BSTR-03	P. Cota X39037 S. McMillan X35913
STS-29-07	TAGS Developer Over Heating	73:19:28 GFE/JSC/ DR-EE649	a) An overtemp indication was received signaling a potential developer over heating. A test pattern was sent to the crew and the image revealed that the center heater was the cause of the indication. The system works nominally if powered up for use, and turned off between uses. Overtemp is expected to recur if powered up for several hours. Remove and replace and send TAGS to JSC for T/S. No further KSC action required. Closed	INCO-03	R. Richards X30203 D. Suiter X33339
		074:10:15	b) At 074:10:15 Gmt and 074:10:28 GMT, the TAGS moded from ready to standby during two separate page uplinks. The mode changes occurred at about the midpoint of the page. The TAGS was commanded to ready, and in both cases, the TAGS went back to ready. Both pages were re-uplinked successfully R/R TAGS. Has been shipped to JSC. No further KSC action required. Closed.	INCO-05	

NASA-JSC

JSC Form 318 (Feb 81)

TABLE II.- STS-29 PROBLEM TRACKING LIST

PROBLEM TRACKING LIST		STS-29/OV103		DATE 4-27-89	PAGE 4
NO.	TITLE	TIME	COMMENTS	MOD NO.	RESP. MGR.
STS-29-08	OPS-2 Recorder Trk 4 Inoperable	074:00:58 GFE-DR-BH930037 PR-INS-A-0020	OPS-2 recorder track 4 would not acquire sync lock when data were dumped. The recorder would not dump properly in forward or reverse at more than one site. Other tracks are OK. Remove and replace, and return recorder to JSC for T/S. Removed and shipped to JSC. Reinstall 4/13.	INCO-04	J. Melugin X33609 M. Suffredini X31735
STS-29-09	PLBD Port B Close Indication Fail	077:10:59 IPR 33RV-0025 CAR/29RF07 PR-MEQ0412	Payload bay door port aft close limit switch in the ready-to-latch module failed to indicate closed. Chit J2953. Appd 3/30. Verified close indication still on. R/R switch module. Removed 4/12. KSC send to Dwny. Verified did not have good switch contact (switch #4). To KSC 5/19.	MMACS-02	W. Acres X38962 J. Guthery 33326
STS-29 10	WSB #3 Low Relief Valve Reseat Press	072:14:56 CAR/29RF09 PR-HYD-3-09-0284	WSB #3 relief valve appears to have reseated, then developed a slow leak approx. 10 min later. It fully reseated at 26.7 psia. S/B 28 psia file IX in flight checkout requirement. Chit 2955 withdrawn. Will C/O to OMI-V1017.		J. Grush X39033 S. McMillan X35913
STS-29 11	WSB #1 Leak	CAR/29RF10 PR-HYD-3-09-0285	WSB #1 exceeded spec leakage 0.6 psia/hr vs .04 psia/hr. Subsequently, leak stopped. Chit J2955 withdrawn. Will C/O to OMI-V1017. RCN I/W at Dwny to revise spec.		J Grush X39033 S. McMillan X35913
STS-29-12	17" Disconnect Leak	Postlanding CAR/29RF11 PR-MPS-3-09-0673	Inspection discovered audible leak in 17" LH2 disconnect. Found nick on flapper seat. Black streak and small nicks on inner bore. PR MPS 3-09-0673. Chit J2954 appd 3/27. Inspection complete. Evaluation in process. 1086 SCM leak, 209 SCM after valve cycled.		P Cota X9037 S. McMillan X35913

TABLE II.- STS-29 PROBLEM TRACKING LIST

PROBLEM TRACKING LIST		STS-29/OV103		DATE 4-27-89	PAGE 5
NO.	TITLE	TIME	COMMENTS	MOD NO.	RESP. MGR.
STS-29-13	LH2 4" Disconnect Slow To Close	072:15:05 CAR/29RF12 IPR33RV-0028	The time from closed power (V41X1439E) applied to closed indication (V41X1420E) was approx. 5 sec. spec is 1.2 sec. max. Chit J2954 appd. KSC has chit I/W. Bellville spring inspection good. R/R disconnect 4/20. Ship to Dwny. Rework and return 6/15. Spare to be installed 6/15.	BSTR-04	P Cota X9037 S. McMillan X35913
STS-29-14	FES Primary Controller "B" Outlet Oscillation	077:10:40 CAR/29RF13 IPR 33RV-0029	During 3 different startups in-flight, the FES control temperature oscillated between 38° and 41° and damped out in approximately 6 cycles. Probable cause lies in the FES Primary B Control or midpoint temp sensors. This phenomena contributed to momentary FES shutdown during entry. Chit J2961A appd 3/31. Ramp tests performed on 3 mid point sensors. Pri A lagged by .4 sec. Repacked and reinstalled sensors. Will retest. 'B' side ok. Retest I/W 4/19. More retest 5/1.		H. Rotter X39249 D. Dillman X31733

JSC Form 318 (Feb 81) NASA-JSC

TABLE II.- STS-29 PROBLEM TRACKING LIST

PROBLEM TRACKING LIST		STS-29/OV103		DATE 4-27-89	PAGE 6
NO.	TITLE	TIME	COMMENTS	MOD NO.	RESP. MGR.
STS-29 15	Plus X Coas Calibration Discrepancies	76:19:37 FIAR BFCE-211-F001	A + X COAS calibration was performed on flight day 3. Three + X calibrations were also performed on flight day 5 during DTO 790 using Vega, Denebola and Arcturus. The three calibrations from flight day 5 differed from the flight day 3 calibration by 0.5 to 0.6 degree in the horizontal axis. Previous flight experience has shown that a COAS can be removed and remounted with essentially repeatable marks. JSC coas at Dwny for evaluation. JSC doing sun filter test. Chit being written to check warpage on panel.	GNC-01	I. Sauleitis x38277 M. Suffredini x31735
STS-29 16	Fuel Cell #1 H2O Relief Valve Temperature Overshoot	74:08:45 IPR33RV-0009 IM/29RF16	Crew configured fuel cell H2O relief heaters to the B auto position per the heater reconfiguration on the morning of flight day 3. The B thermostat immediately turned the heater on since its temperature was 70°F. The temperature rose to 130° before a normal cooldown of the H2O line was observed. STS-26 data on this thermostat showed that the temperature never rose above 105°F during its cycling when OV-103 was in a cool attitude. Thermostat was removed & replaced at KSC prior to STS-29 flight. Chit J2948 appd 3/21. (PRSD system checks). V1022 will retest next week. KSC work chit week of 4/10. Swap #1 & #2 thermostat and retest week of 5/10.	EECOM-03	F. Plauche X39034 D. Dillman X31733

NASA-JSC

JSC Form 318 (Feb 81)

TABLE II.- STS-29 PROBLEM TRACKING LIST

PROBLEM TRACKING LIST		STS-29/OV103		DATE 4-27-89	PAGE 7
NO.	TITLE	TIME	COMMENTS	MOD NO.	RESP. MGR.
STS-29 17	SSME #1 LH2 Prevalve Signature Anomaly	Prelaunch IM/29RF17	SSME #1 LH2 prevalve signature was slow compared to previous operations. May be sample rate problem. No KSC action required. Closed.		P. Cota X39037 S. McMillan X35913
STS-29 18	LH OMS Fuel Gage Ungageable Quantity	PR-LP04-A0013 Deferred Waiver - WK0914 (29 only) IM/29RF18	LH fuel gage total channel output had ungageable qty locked in during OMS-2 and OMS-3. Readings were correct after deorbit burn. OMS pod removal planned. Gage will be repaired. Totalizer checkout unit will be hooked up and gage tested week of 4/24 prior to pod removal. Dry probe reading 8% bias. More T/S in HMF.		J. Hooper X39031 T. Welch X33335
STS-29 19	AFT Separation Hole Plugger Did Not Move Full Stroke	PVR-3-09-0101 PR-PYRO-0101 CAR/29RF19	Postflight inspection at DFRC showed that the AFT separation hole plugger did not fully extend the piston. First failure since MOD. Debris in plunger was part of initiator. Dwny to submit closeout to JSC. KSC to pull and send to DWNY.		N. Piercy X38950 J. Guthery X33326
STS-29 20	Unable To Dump OPS-1 Recorder, Track 2	75:07:18 IPR33RV-0008 IPR-QA960036	Data playback of OPS-1 recorder, Track 2 through TDRS & GSTDN unsuccessful. Data on adjacent tracks are locked up on with better results. Occured again during postlanding dump of entry data when DFRC could not lock onto Track 2 data. J2968 PRCB 4/4 appd. Successful dump at KSC. Chit I/W 4/17. T/S 4/25 showed normal. Close as U.A.	INCO-7	J. Melugin x33609 M. Suffredini x31735

NASA-JSC

JSC Form 318 (Feb 81)

TABLE II.- STS-29 PROBLEM TRACKING LIST

PROBLEM TRACKING LIST		STS-29/OV103		DATE 4-27-89	PAGE 8
NO.	TITLE	TIME	COMMENTS	MOD NO.	RESP. MGR.
STS-29 21	MPS LH2 Feed Manifold Leak	IM/29RF21	Previous flights showed several relief valve cycles. This flight, the relief valve cycled once. Investigation in process. Dwny saw same profile last 103 flight. Providing rationale to JSC for problem closeouts. No KSC action required.		P. Cota x39037 S. McMillan x35913
STS-29 22	RH Main Landing Gear Strain Gage Harness Separation	Touchdown PR-MWA-22-0012 IM/29RF22	The RH main landing gear strain gage wiring and connector came loose and was found on runway. Suspected to have caused tile damage found on door. Terminal bd not properly tied down in RH wheel well. Was proper on LH gear. KSC replace terminal board. Reviewing tie-wrap photos. Config. per DWG. Close out photos bad. Tie wraps installed properly. Damage repaired. Close.		C. Campbell x38948 J. Guthery x33326
STS-29 23	Hydraulic Leak In Aft Compartment	PR-HYD-3-09-0282 IM/29RF23	Postflight inspection found hydraulic fluid in the aft compartment. Inspection found loose 'B' nut in leakage collection line from SSME-1 accumulator. One half to one ounce of hydraulic fluid found. Torqued "B" nut at DFRC for ferry. Will lk ck again as part of OMI. KSC investigating why "B" nut loose. Paper work shows 'B' nut torqued properly. Install "catch bottles". Retorque. Close.		J. Grush x39033 S. McMillan X35913

NASA-JSC

JSC Form 318 (Feb 81)

TABLE II.- STS-29 PROBLEM TRACKING LIST

PROBLEM TRACKING LIST		STS-29/OV103		DATE 4-27-89	PAGE 9
NO.	TITLE	TIME	COMMENTS	MOD NO.	RESP. MGR.
STS-29 24	Intermittent Aft Auto Dap Light	IM/29RF25	During crew debriefing, the crew stated that on one occasion the Aft Auto Dap Light was not illuminated while the forward Auto Dap Light was illuminated. A lamp test indicated that the lamp was operational. At some point later, it was noted by the crew that the Aft Auto Dap Light was illuminated. KSC will T/S per IPR 33RV0017. T/S 4/20 and 4/21. On and cycled but couldn't recreate problem.		E. Dickinson X31717 W.Leverich X30960
STS-29 25	Aft (1307) Bulkhead Thermal Blankets Loose and Excessive Particulate Contamination in PL Bay.	IM/29RF24	KSC inspection found top (2) blankets torn on bulkhead side. Found loose snaps on top of blankets found total of (4) blankets peeled back. Two each side of upper CL. Suspected cause is increase in air volume under blankets after 1307 beefup MOD. For STS-30/OV104, will install air vent screens in top two blankets. OV103 will remove all blankets and map entire 1307 bulkhead for damage and debris. 12 blkts pulled and debris mapped. 103 wait for any further action. MCR 14725 Dwny MOD. Complete Eng. by next week. Excessive contamination cleaned up. Insp. and cleanup plan for OV104 in work. PR-TCS-3-09-1158. 4/25 104 insp all looked good. 103 material failure due to excessive flexing, bending folding. KSC lab report to JSC.		L. Palmer X38877 J. Guthery X33326

NASA-JSC

JSC Form 318 (Feb 81)

PROBLEM TRACKING LIST		STS-29/OV103		DATE 4-27-89	PAGE 10
NO.	TITLE	TIME	COMMENTS	MOD NO.	RESP. MGR.
STS-29 26	Hyd System 1&2 Accumulator Ascent Press Locked up Low		During STS-29 Ascent at APU shutdown, Hydraulic system 1 and 2 GN2 Accumulator pressures locked up low, 2496 psia and 2464 psia, respectively, and then crept up to acceptable levels (2600). Chit J2956 PRCB 4/6 appd. Monitor lock up pressure. First look FRI 4/21.		J. Seriale-Grush X39033 S. McMillan X35913
STS-29 27	Tacan #2 Dropped Lock Postlanding	IM/29RF28 PR-COMM-140	IPR 733 RV0007. Tacan 2 lost bearing and range lock postlanding. Will be R/R week of 4/17.		R. Nuss X31484 D. Suiter X33339
STS-29 28	LH2 OUTBD Fill and Drain Valve slow closing at Dump Termination	72:15:09:51	LH2 outbd fill/drain valve slow close at dump termination. 11.5 sec actual vs 10 sec. spec. was observed in post flight data review. LCC changed to 13 sec. Engineering review in work. STS-27 similar problem.		P. Cota X39037 S. McMillan. X35913
STS-29 29	Wireless Comm. Set Multiple Batt. Changes		Crew reported changing batteries too often. Batteries known to be marginal. This lot of batteries removed from flight status. Better lot available. New design in process. No KSC action.		R. Armstrong X1440 D. Suiter X33339
STS-29 30	RH Outboard Brake Rotor Crack		Post flight inspection of the RH outboard brake assy at the vendor found a crack in the rotor. This occurred during the hard braking DTO and was not unexpected. Dwny send copy of vendor insp. report.		C. Campbell X38948 J. Guthery X33326
			4-27-89 David W. Camp David W. Camp Manager, Flight Evaluation Office		

NASA JSC

JSC Form 318 (Feb 81)

NASA Headquarters
QP/N. R. Schulze
LB-4/G. L. Roth
MO/G. Krier
MOJ/C. Perry
ML/W. Hamby
MVS/N. Frandsen

Goddard Space Flt Ctr
400/W. Keathley
400/R. L. Baumann
700/J. H. Boeckel
710/T. E. Huber
730/E. I. Powers
731/E. W. Travis
730.1/J. P. Young
420/J. Barrowman (6)
302/W. F. Bangs
313/R. Marriott

KSC
NWSI-D/Respository (25)

MSFC
AS24D/Respository (30)
EP51/J. Redus (5)
EL74/P. Hoag (5)
FA51/S. P. Sauchier
JA01/J. A. Downey
SA12/O. E. Henson

Langley Research Center
Technical Library/
Mail Stop 185

Rockwell-Downey
AD75/Data Management (55)

Rockwell-Houston
RS12/A. Coutret (10)
RS12/L. A. Jared
ZC01/R. Filler
ZC01/D. Coronado
ZC01/D. McCormack
R16G/J. Woodard

JSC
AA/A. Cohen
AA/D. A. Nebrig
AC5/J. W. Young
AP3/J. E. Riley (4)
AP4/B. L. Dean (3)
BL/W. L. Draper
BY4/History Office (2)
CA/D. R. Puddy
CA/D. C. Brandenstein (5)
CB/M. L. Coats (5)
CB/K. Colgan
DA/E. F. Kranz
DA/J. W. O'Neill
DA8/T. R. Loe
DA8/Library
DF/S. G. Bales
DF72/Q. Carelock
DF75/D. Nelson
DG/R. K. Holkan
DH4/R. D. Snyder
DH45/E. B. Pippert
DH4/J. F. Whitely
DM/J. C. Harpold
DM/C. F. Deiterich
EA/H. O. Pohl
EC/W. W. Guy
EC2/D. F. Hughes
EC3/F. H. Samonski (2)
EC4/L. O. Casey
EC6/E. Winkler
EC6/J. W. McBarron (5)
EC6/D. M. Hoy
ED3/R. Barton
EE/R. S. Sawyer
EE/J. H. Johnson
EE/S. E. Davidson
EE2/H. A. Vang
EE7/M. D. Schmalz
EE7/O. L. Schmidt
EE7/J. C. Dallas
EF/R. M. Kurten
EF3/J. A. Lawrence
EH/K. J. Cox
EH/R. E. Lewis
EH/P. E. Sollock
EH2/P. C. Kramer
EH2/J. E. Yeo
EH2/O. P. Littleton
EH3/D. Gilbert
EP/C. A. Vaughn
EP2/H. J. Brasseaux
EP2/L. Jenkins
EP5/C. R. Gibson
ES/D. C. Wade
ES12/W. G. McMullen (2)
ES3/J. A. Smith
ES3/L. D. Palmer
ES6/R. Balciunas (2)
FA/R. L. Berry
FA/J. R. Garman
FD6/S. Morris
FM/E. C. Lineberry (8)
FM/E. R. Schiesser
FR/E. S. Chevers
FR/SSD Library
FS/J. W. Seyl (2)
GA/R. H. Kohrs
GM/D. C. Schultz
JL4/R. L. Squires
JM2/Library (3)
MA/A. D. Aldrich
MJ/R. Thorsen
NA/C. S. Harlan
NB/D. L. Duston
ND/T. J. Adams
NS/J. H. Greene
SA/C. L. Huntoon
SD/S. L. Pool
SD2/J. R. Davis
SD24/D. A. Rushing
SD4/N. Cintron
SD5/J. Charles
SE/J. H. Langford
SN3/D. Pitts
SP/C. D. Perner (5)
TA/L. S. Nicholson
TA/L. G. Williams
TA/H. M. Draughon
TA/R. L. Blount
TC2/H. Lambert (5)
TC12/P. S. Jaschke
TJ/L. E. Bell
TJ2/G. W. Sandars
TM2/J. Bates
VA/R. A. Colonna
VA/D. M. Germany
VA/G. A. Coultas
VE/P. C. Glynn
VE3/M. C. Coody
VE4/W. H. Taylor
VF/J. E. Mechelay
VF2/W. J. Gaylor
VF2/R. W. Fricke (25)
VF2/B. Johnson
VF2/C. Critzos
VF3/D. W. Camp
VF3/T. Welch (3)
VF4/E. R. Hischke
VF5/S. M. Andrich
VG/F. Littleton
VK/J. Presnell
VP/C. McCullough (3)
VR/D. D. Ewart
WA/R. W. Moorehead
WC/F. T. Buzzard
WE/R. D. White
WG/J. C. Boykin
ZR1/Lt. Col. G. Janson
ZR12/J. A. Yannie
BARR/V. Whynott (3)

ECHS/Hamilton Standard

External Distribution
Mr. Willis M. Hawkins
Senior Advisor
Lockheed Corporation
P. O. Box 551
Burbank, CA 91520

External Dist (cont)
Dr. Richard H. Battin
Associate Department Head
Charles Stark Draper Lab., Inc.
555 Technology Square
Cambridge, MA 02139

Lt. Gen. Leighton I. Davis
USAF (Ret.)
729 Stagecoach Road,
Four Hills
Albuquerque, NM 87123

Mr. Herbert E. Grier
Consultant - Suite 304
2223 Avenida de la Playa
La Jolla, CA 92037-3294

Mr. Ira Grant Hedrick
Presidential Assistant for
Corporate Technology
Grumman Aerospace Corp
Bethpage, NY 11714

Dr. Seymour C. Himmel
12700 Lake Avenue, #1501
Lakewood, OH 44107

Mr. John F. McDonald
Vice President-Technical
Services
TigerAir, Inc.
3000 North Claybourn Ave
Burbank, CA 91505

Dr. John G. Stewart
Manager, Office of
Planning and Budget
Tennessee Valley
Authority E6C9
400 Commerce Avenue
Knoxville, TN 37902

R. Birman
Room 10A23
General Electric Co.
Space Division
P. O. Box 8555
Philadelphia, PA 19101

TRW
Houston, TX 77058
Attn: C. Peterson/H5

R. Hoey
6510 Test Wing/TEG/236
Edwards AFB, CA 93523

External Dist (cont)
Headquarters, Space Div
Attn.: SD/CFCT
Los Angeles AF Station
P. O. Box 92960
Worldway Postal Center
Los Angeles, CA 90009

John Williams
1995 Ferndale Place
Thousands Oaks, CA 91360

Dr. K. H. Doetsch
National Aeronautical
Establishment
National Research
Council of Canada
Ottawa, Canada K1A OR6

Darryl Strickland
3906 Annadale Lane
Apt 132
Sacramento, CA 95821

B. A. Aikenhead
National Aeronautical
Establishment
National Research
Council of Canada
Ottawa, Canada K1A OR6

T. W. Ussher (2)
SPAR Aerospace Limited
1700 Ormont Dr.
Weston, Toronto, Ontario,
Canada M9L 2W7

J. Middleton
SPAR Aerospace Limited
825 Calendonia Road
Toronto, Ontario,
Canada M6B 3X8

N. Parmet
5907 Sunrise Drive
Fairway, Kansas 66205

R. Peterson
Mail Stop 351-4A
Minneapolis - Honeywell
Avionics Division
13350 Hwy 19
Clearwater, FL 34624

Lockheed Engineering and
Sciences Co.
2400 NASA Road 1
Houston, TX 77058
C-07/Library

External Dist (Concluded)
C. Wiltsee (4)
Mail Stop 244-14
Code SP
Ames Research Center
Moffett Field, CA 94035

AFTEX/OL-BF (2)
Patrick AFB, FL 32925

Aerospace Corporation
P. O. Box 92957
Los Angeles, CA 90009
Attn: W. Smith, M5/714

McDonnell Douglas-Houston
D2/M. D. Pipher
T3A/A. D. Hockenbury

D. Molgaard
Mail Station 135-6861
TRW Systems-1 Space Prk
Redondo Beach, CA 90278

L. R. Adkins/IBM Bldg
Mail Code 9236
1322 Space Park Drive
Houston, TX 77058

James R. Womack
JPL/233-307
4800 Oak Grove Dr
Pasadena, CA 91109

T. Myers, Sys Tech, Inc.
13766 So. Hawthorne Blvd.
Hawthorne, CA 90250

Mr. James V. Zimmerman
NASA European Rep
c/o American Embassy
APO New York, NY 09777

J. R. Cretcher 6223/577N (2)
Lockheed Astronautic Div
Astronautic Engineering
Information Center
P. O. Box 3504
Sunnyvale, CA 94088

Commanding General
U. S. Army Logistics Center
Attn: ATCL-PS/Col. Senegal
Ft. Lee, VA 238001-6000

Capt. J. Behling
6555 ASTG/SMSP
Cape Canaveral AFS, FL. 32925

Notify VF2/R. W. Fricke (FTS-525-3313) of any correction, additions, or deletions to this list.